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Computational Studies of Projectile Melt in Impact with Typical Whipple Shields[1]

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ABSTRACT

Protecting space-based structures against the impact of orbital debris is an important problem of current interest. This paper presents scaling results based on simulations with the **CALE** computer program of aluminum projectile impacting typical aluminum Whipple shields at speeds of 6 to 14 km/s. The objective was to determine the extent of projectile and shield material melting. The approach was to perform a matrix of computer simulations varying the impact speed from 6 to 14 km/s and varying the areal density of the shield from 5 percent to 80 percent of the centerline areal density of the projectile. The projectile radius was fixed at 9.5 mm (mass = 1.27 grams). The melt state of the projectile material and the shield material was assessed after release of the initial shock. The post-release specific energy in the projectile and in the shield was compared with the enthalpy of incipient melt and the enthalpy of complete melt provided in the Hultgren Tables. Material with specific energy greater than the enthalpy of complete melt was assumed to be fully melted. Material with specific energy greater than the enthalpy of incipient melt but less than that of complete melt was assumed to be partially solid and partially melted mixed phase material with no strength. Material with specific energy less than the enthalpy of incipient melt was assumed to be in a solid state with strength. It is likely that this solid material is in a highly fragmented state as a result of the initial shock.

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